

Metacognition Process of Students Class X Senior High School in Mathematic Problem Solving

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Abstract: The aimed of his study is to describe the process of students' metacognition in solving mathematics problems. The subject of the study is six senior high school students in tenth grade. Data were collected using a written test, think aloud, interviews, and journal metacognitive. Data analysis of the process of metacognition of each subject was based on each of the indicators awareness, evaluation and regulation. The finding shows that in general, metacognitive awareness, metacognitive evaluation, and metacognitive regulation occur when subject solving mathematics problem. Metacognitive awareness occurs when the subject understand the given problem with the advent of the indicators the subject rethink what is known from the given problem, ie when the subject reads the questions repeatedly and focus on known information. Metacognitive regulation occurs when the subject changes the method that he used to solve the problem of sequence and when the subject recheck the number of lines repeatedly before making a conclusion that the number of lines can be searched by using a pattern or the method used to find. Metacognitive evaluation occurs when the subject assesses steps of working on the problem, with the indicators of an assessment of the results obtained and the assessment of the effectiveness of the strategy selected, ie when the subject believes the solution obtained was appropriate because they counted the number of lines formed by using various strategies and repeatedly.

Keywords: metacognition, problem solving

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I. Introduction

One of the standard process that should exist in mathematics is problem solving. NCTM (2000) states that problem solving in mathematics should enable students to build new mathematical knowledge, solving problems related to mathematics or any other context, to try and adapt to a variety of strategies to solve problems, and to monitor and reflect on the process of mathematical problem solving.

The activity of monitoring and reflecting on the process of mathematical problem solving performed by students can lead to the appearance of its consciousness of what he is thinking. Students' awareness of what he is thinking and the ability to monitor their own process is known as metacognition (Laurens, 2010).

Metacognition is a cognition about cognition or thinking about thinking (Huit, 1997; Livingstone, 1997). Davis (2015) states that metacognition is the term used to describe the processes involved when students plan, monitor, evaluate, and change the way their own learning.

In mathematical problem solving, metacognition helps troubleshooter to acknowledge the problems that need to be resolved, to distinguish what exactly the problem, and to understand how to achieve the goals or the solution of the problem (Kuzle, 2013). Davidson and Stenberg (1998) states that metacognition allows the troubleshooter to identify and work according to the plan that has been created.

Wilson and Clarke (2004) states that there are three metacognitive activities involved when students solve mathematical problems, namely *metacognitive awareness*, *metacognitive regulation*, and *metacognitive evaluation*. According to Wilson and Clarke (2004), *metacognitive awareness* is related to the individual's awareness of its existence in the process of problem solving, specialist knowledge of the problems faced, and knowledge of strategies to solve problems. *Metacognitive awareness* also includes knowledge of what needs to be done, what has been done, and what might be done in the process of solving the problem. Furthermore, he stated that *metacognitive evaluation* refers to the judgments made about the process of thinking, the capacity to think, and the limitations of themselves when working in certain situations, while *metacognitive regulation* occurs when someone uses metacognitive skills to organize knowledge and thinking. *Metacognitive regulation* refers to a person's knowledge about a strategy, including how and when to use specific strategies and the use of executive skills such as planning, correcting, setting a goal to optimize the use of their own cognitive resources.

Research on students' metacognition in solving mathematical problems were conducted by several researchers, including Desoete (2001), Wilson and Clarke (2004), Panaoura (2009), Kuzle (2013), Magiera and

Zawojewski (2011), and Purnomo, Toto, Subanji, and Swasono (2016). In general, the study discusses the process of students' metacognition in solving mathematical problems.

In the research conducted by Wilson and Clarke (2004) and Purnomo, Toto, Subanji, and Swasono (2016), *metacognitive awareness*, *metacognitive evaluation*, and *metacognitive regulation* always occur on any subject when he solved a mathematical problem. When examined, these two studies were using metacognitive action card that had been prepared previously. Action cards are used to tell metacognitive process of problem solving sequence performed by the students. This raises a question, what if it was not using the metacognitive action card. Will every subjects experience cognition activity and whether the three activities of metacognition mentioned will be experienced on every subjects when solving mathematical problem. Based on this matter, thus it was conducted a research entitled metacognition process of students class X senior high school in mathematic problem solving.

II. Research Methodology

This study is included in descriptive exploratory study aimed to describe the process of students' metacognition in solving mathematics problems in depth and in general. Subjects in this study were 6 students class X Senior High School. Subjects were selected based on the student's ability in solving mathematical problems in the material of sequence and the student's ability to communicate his thinking process. Data of student's ability in solving mathematical problems were obtained by using test done by students. The results of the tests were grouped into three categories of students' ability to solve problems, namely: high, medium, and low. From each category it was selected two students as the research subjects.

Data were collected using a written test, think aloud, interviews, and journal metacognitive. The written test consisted of one problem solving of sequence materials. At the time the subjects were working on the written test, the subjects were asked to verbally express notion or idea in mind when solving problems. Shortly after completing the test, the researcher conducted interviews with the study subjects to obtain more in-depth information about the student metacognition. Subsequently, subjects were asked to fill out a journal of metacognitive.

Data that have been obtained were then analyzed to determine the metacognitive processes of each of the research subjects. Data analysis of the process of metacognition of each research subject was based on each of the indicators awareness, evaluation and regulation.

III. Results

The metacognitive process of each subjects in solving problem of sequence were as follows.

Metacognitive process of subjects with high skills

The process of problem-solving of subjects were started by cognitive activity at the time of reading a question given and made a circle with 18 points in the circle. Then, he experienced metacognitive awareness activity at the time he realized the past knowledge it would help to solve a problem, namely that to make a line at least it needs two points. Back to the cognitive, he connected the points with a line and calculated the number of lines formed such as shown on Figure 1.

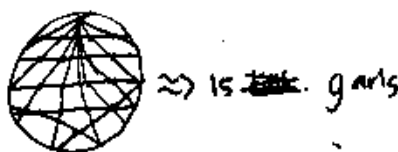


Figure 1 First work of subject S-1

In the next phase, he experienced a metacognitive regulation activity because he was rethinking the measures he chose to try other patterns as seen in Figure 2 and forwarded to metacognitive awareness when he thought back that to form a line at least it requires a minimum of two points.

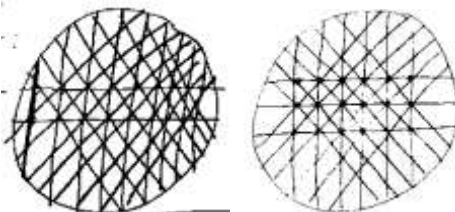


Figure 2 Second work of subject S-1

Back to cognition, he made a line connecting the dots and count the number of lines formed were 18 and 21. Subsequently, he entered the metacognitive awareness when he rethink the answers obtained in the first calculation. In the next phase, subject S-1 experienced a metacognitive regulation activity because he was

thinking about another way, when he thought that many lines can be searched by calculating the multiplication 18×17 . The results of *metacognitive regulation*, then obtained the number of lines amounted to 306. Furthermore, subject S-1 experienced a metacognitive evaluation activity because of doubts about the results obtained. Then entered metacognitive regulation activity when thinking about other ways to resolve the problem as in figure 3 and metacognitive evaluation when he evaluated the process steps.

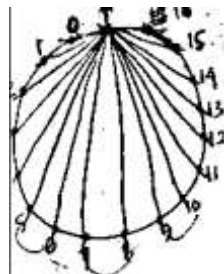


Figure 3 Fifth work of subject S-1

Back to the area of cognition at the time he wrote the steps to work on and ended by metacognitive evaluation when he checked again the steps used to solve the problem..

The activity to solve the problem by subject S-2 was commenced by cognition when he read the given issue and drew a circle with 18 points inside the circle. In the next phase, he experienced metacognitive awareness activity, that is, when he thought about it over and over again and gave emphasis on the information known, that the number of lines were in total of 18. Back to the are of cognition, he counted the number of lines formed totaled 9 and entered metacognitive evaluation activity because he believed his results. Furthermore, subject S-2 had metacognitive regulation activity because he was thinking of other ways as shown in Figure 4.

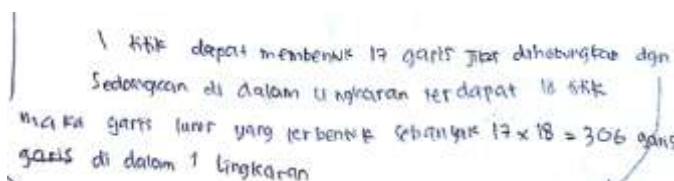


Figure 4 Second method by subject S-2 in solving problem

Back to the area of cognition when he counted the number of lines by multiplying $17 \times 18 = 306$ and entered metacognitive evaluation activity when he evaluated the steps he used by repeating the process of finding the method. At some later stage, subject S-2 had metacognitive regulation activity because he was thinking about another way as shown in Figure 5.

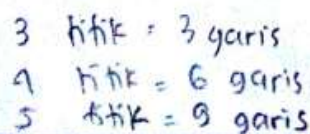


Figure 5 Third method by subject S-2 in solving problem

Back to the area of cognition, he looked for patterns in the data and found that the number of the line formed were in total of 63. Subsequently, he experienced metacognitive regulation activity when he rethink plans made to solve the problem as seen in Figure 6, and ended in the area of cognition when he had calculated the lines formed were in total of 143.

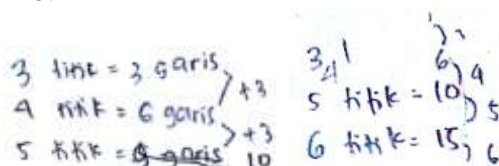


Figure 6 Fourth method by subject S-2 in solving problem

The process of metacognition subject S-1 and S-2 subject are represented in figure 7 below.

S-1

S-2

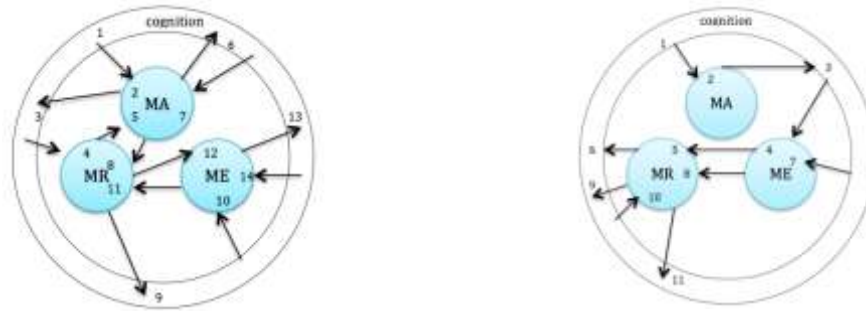


Figure 7 Metacognition process by subject S-1 and subject S-2

Metacognition process with above-intermediate skills

Subject S-3 began to solve the problem by reading the given problem. Furthermore, subject S-3 experienced metacognitive awareness activity when he decided to rethink the information known and what is being asked. Back to the area of cognition, subject S-3 made a circle with eighteen points on the circle and created a line connecting the dots as he counted. In the next phase, he experienced a metacognitive regulation activity when he changed the way people used to count the number of lines as shown in Figure 8.

$$\begin{array}{r}
 18 \\
 18 \\
 \hline
 144 \\
 18 \\
 \hline
 324
 \end{array}$$

Figure 8 Work by subject S-3

Back to the area of cognition, subject S-3 created a new circle and eighteen points. Furthermore, subject S-3 experienced metacognitive evaluation activity, ie when subject S-3 recalculated and assessed the results of its work properly. Entered to metacognitive regulation, subject S-3 looked back the way he thought and changed the way he used to solve the problem. Back to the area of cognition, subject S-3 wrote the results obtained. Furthermore, subject S-3 experienced metacognitive evaluation activity when assessing the correct process and entered metacognitive regulation activity when changing solving strategies using the sequence of 17, 16, 15, 14, ..., 1, 0. Back to the area of cognition to resolve the problem and ended with metacognitive evaluation activity when calculating the sum repeatedly and believed that the number of lines can be searched by the sum $17 + 16 + 15 + 14 + \dots + 3 + 2 + 1$.

In the early stages, subject S-4 experienced cognitive activity, that is, when he read a given problem and look for the number of lines formed from a single-point, two points, three points and four points. The results of the cognitive activity, he found that the number of line formed of one point, two point, three point, and four points formed a pattern. Furthermore, subject S-4 developed metacognitive activity regulation when he decided to test the pattern he found by using a five-point. Back to the realm of cognition, subject S-4 counted the number of lines formed manually and using patterns he found. In the next stage he experienced the activity of metacognitive awareness that is when he realized that the patterns found previously can be used to solve a given problem. Back to the realm of cognition, subject S-4 counted the number of lines if there are 18 points as shown in Figure 9.

$$\begin{aligned}
 U_{18} &= 0 + 1 + 2 + 3 + 4 + 5 + 6 \\
 &\quad + 7 + 8 + 9 + 10 + 11 + 12 \\
 &\quad + 13 + 14 + 15 + 16 + 17
 \end{aligned}$$

Figure 9 Answers by subject S-4

Entering *metacognitive regulation*, he used a strategy to sum by summing the initial numbers with final numbers $((0 + 17) + (1 + 16) + \dots + (8 + 9))$ to accelerate the process of calculation. Back to the realm of cognition, subject S-4 counted the number of lines formed. Furthermore, subject S-4 developed metacognitive activity regulation, when he tried to solve the problem in another way (to calculate manually) as shown in Figure 10.

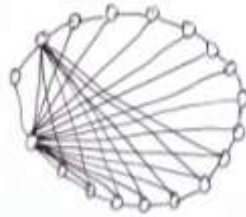


Figure 10 Second method used by subject S-4

Entering *metacognitive evaluation* when assessing the effectiveness of manual method, and entered into *metacognitive regulation* when he tested the pattern he found at the beginning by using six point. In the last stage, subject S-4 developed *metacognitive evaluation* activity for assessing the results of his work is proper. The process of metacognition by subject S-3 and S-4 can be represented in figure 11 below.

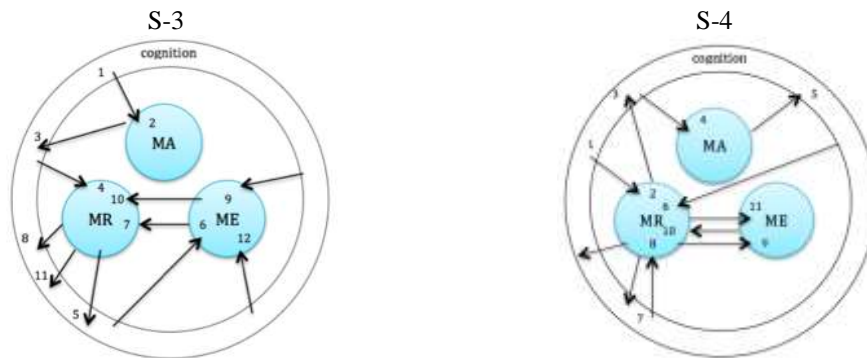


Figure 11 Metacognition process by Subject S-3 and S-4

The process of metacognition by subject of low ability

Two subjects in this category have not experienced metacognitive evaluation activity at the time of solving the problem. Furthermore, one of the two subjects experienced cognitive activity, he did not experience metacognition activity when solving a given problem. Here is the process of solving the problem of the two subjects.

Subject S-5 started to solve the problem by reading the given problem. In the next phase, he multiplied eighteen multiplied by eighteen. This was because there were eighteen points that led to many relationships of each point there were eighteen. Note the transcript of the interview follows..

Subject PML: "...there are eighteen points, that means also eighteen, so one point to another point is connected ..., eighteen, so eighteen times is the connection so it is eighteen multiplied by eighteen..."

The final results obtained by subject S-5 is that there are 324 line formed.

The process of solving by subject S-6 began with cognition activity when he understood the given problem and drew a circle with eighteen points as shown in Figure 12.



Figure 12 Circles made by subject S-6

Furthermore, subject S-6 experienced a metacognitive awareness activity, that is, when he read the questions repeatedly and rethink what is known from the problem. Back to the realm of cognition, subject S-6 started to look for the number of lines to create a line connecting the dots. In the next phase, subject S-6 entered metacognitive regulation that is when he decided to keep looking for the number of lines manually although it will take a long time. Back to the realm of cognition, subject S-6 continued to make a line and counted the number of lines. Entering metacognitive regulation when he changed the method he used by using comparisons $\left(\frac{1}{18} = \frac{17}{x}\right)$, and returned to the cognition to resolve the problem.

The process of cognition or metacognition subject S-5 and S-6 can be represented in figure 13 as follows.

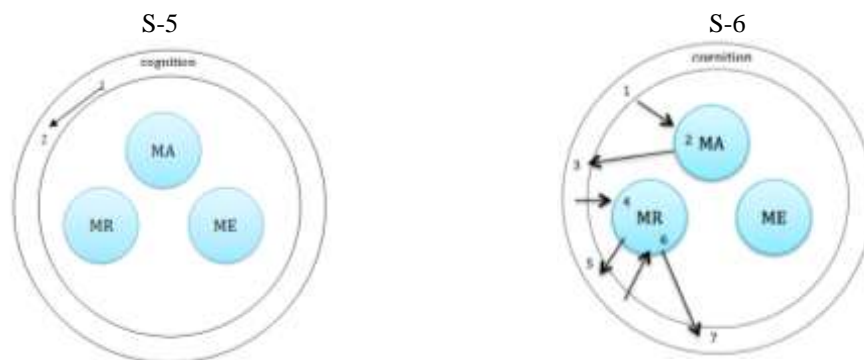


Figure 13 Metacognition process Subject S-5 and Subject S-6

IV. Discussion

The results of the above study indicates that in general the process of solving mathematical problems of the student involved cognition and metacognition activities. Activity of metacognition consists of metacognitive awareness, metacognitive regulation, and metacognitive evaluation.

Metacognitive awareness occurs when students realize that he should read the questions repeatedly to better understand the given problem and when students are aware of previous knowledge can help in resolving the problem. This is in line with Setyadi, Subanji, and Makbul (2016) that the relevant knowledge known to be associated with the problem is metacognitive awareness. According to Joseph (2010), metacognitive awareness is the ability to reflect on their own and develop their thought in learning or solve problems. Metacognitive awareness allows students to plan, sort out, and monitor how to learn to improve its performance (Scraw and Dennison, 1994).

In addition to an awareness of their own thought processes, metacognition also includes the ability to regulate the process of cognition itself. Schoenfeld (1992) states that metacognition can be used to monitor and regulates the process of problem-solving process, as in analyzing the problem, makes a plan, implements the plan, and verifies the answers obtained. The process of verifying or assessing the answers obtained can be regarded as metacognitive evaluation activity (Purnomo, Toto, Subanji, and Swasono, 2016).

In this study, *metacognitive evaluation* does not only occur when students assess the results of his work, but also occurs when students assess the effectiveness of the strategies used. Magiera and Zawojewski (2011) stated that the assessment of the effectiveness of the strategy used is *metacognitive evaluation*.

After experiencing *metacognitive evaluation activity*, most students experience metacognitive regulation. Metacognitive regulation refers to the mental activity that is used to regulate cognitive strategies to solve problems (Jacobse and Harskamp, 2012). For example, when students change the method used to solve the problem, the decision to do so is a metacognitive regulation while when he wrote it in a worksheet is a cognitive activity.

Wilson and Clarke (2004) states that one's knowledge of strategy and when to use these strategies are metacognitive regulation. The results showed that metacognitive regulation occurs when students look back on the circle image and eighteen points he had made and decided to change the location of these points. Metacognitive regulation also occurs when students recheck the number of lines repeatedly before making a conclusion that the number of lines can be searched by summing the row she had already found. Purnomo, Toto, Subanji, and Swasono (2016) states that checking answers repeatedly before making a conclusion is one of the characteristics of metacognitive regulation. Furthermore, the results also showed that metacognitive regulation occurs when students think of other ways that can be used to solve the problem. This is in line with Wilson and Clarke (2004) and Magiera and Zawojewski (2011) that a person's thinking about other methods to solve a problem is a metacognitive regulation.

However, not every students who experienced metacognitive evaluation activity will experience metacognitive regulation activity. Some students were aware that they were not correct or they knew the presence of an error, but they could not make better of the error (Setyadi, Subanji, and Makbul, 2016). According to Laurens (2010), to obtain optimal results it needs interaction between metacognitive knowledge and metacognitive experience, meaning that students should have more than metacognitive knowledge, it needs experience or skills of metacognitive in solving a problem.

V. Conclusion

Through the results obtained above, it is known that there are students who only experience cognition activity when solving mathematic problem. However, in general, the activity of metacognition such as *awareness*, *regulation*, and *evaluation* takes place when a subject solves a mathematic problem.

Metacognitive awareness occurs when the subject understand the given problem with the advent of the indicators the subject rethink what is known from the given problem, ie when the subject reads the questions repeatedly and focus on known information, metacognitive regulation occurs when the subject changes the method that he used to solve the problem of sequence and when the subject recheck the number of lines repeatedly before making a conclusion that the number of lines can be searched by using a pattern or the method used to find and metacognitive evaluation occurs when the subject assesses steps of working on the problem, with the indicators of an assessment of the results obtained and the assessment of the effectiveness of the strategy selected, ie when the subject believes the solution obtained was appropriate because they counted the number of lines

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